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(54) **LINE-WIDTH MEASUREMENT DEVICE AND MEASUREMENT METHOD USING THE SAME**

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CPC ***G01C 11/025*** (2013.01); ***G01B 11/02*** (2013.01); *G01B 2210/56* (2013.01); ***G01N 21/95684*** (2013.01)

(58) **Field of Classification Search**
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USPC 348/135–137, 142, 180, 182, 188, 187; 382/108, 109, 165
IPC H04N 7/18, 17/00, 17/02
See application file for complete search history.

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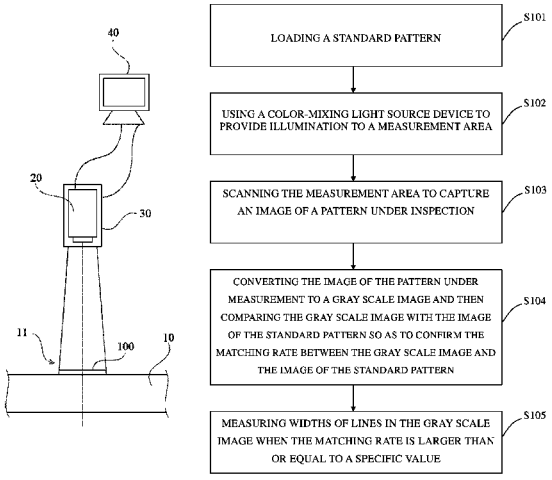
(57) **ABSTRACT**

A line-width measurement device and a measurement method using the same are disclosed. The line-width measurement device has a platform, an image capturing device and a color-mixing light source device. The image capturing device captures an image of a pattern under measurement in a measurement area of the platform. The color-mixing light source device correspondingly provides illumination to the measurement area. The color-mixing light source device has a plurality of monochromatic light sources and adjusts the brightness scale of each monochromatic light source according to the matching rate of the pattern under measurement and a standard pattern to provide suitable color-mixed lights for illumination. Therefore, the present invention can provide a better measurement environment to further enhance accuracy of line-width measurement.

13 Claims, 5 Drawing Sheets



(51) **Int. Cl.**
G01N 21/956 (2006.01)

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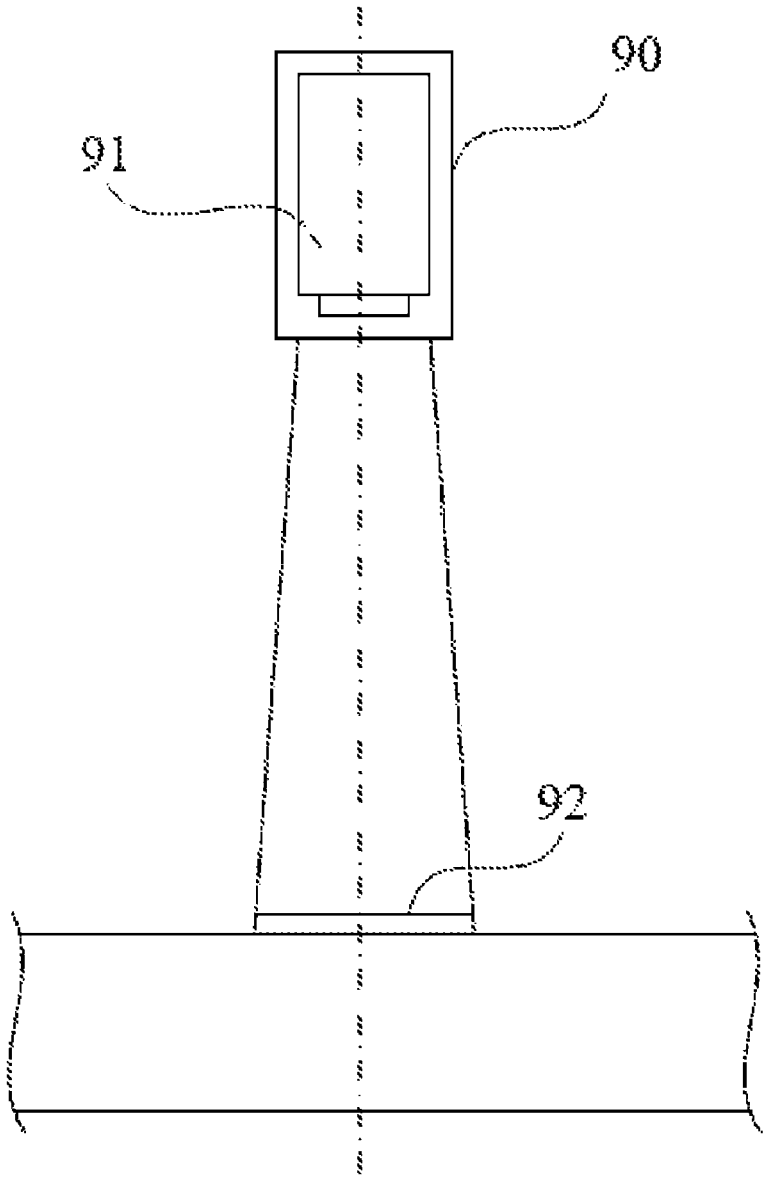

FIG. 1
PRIOR ART

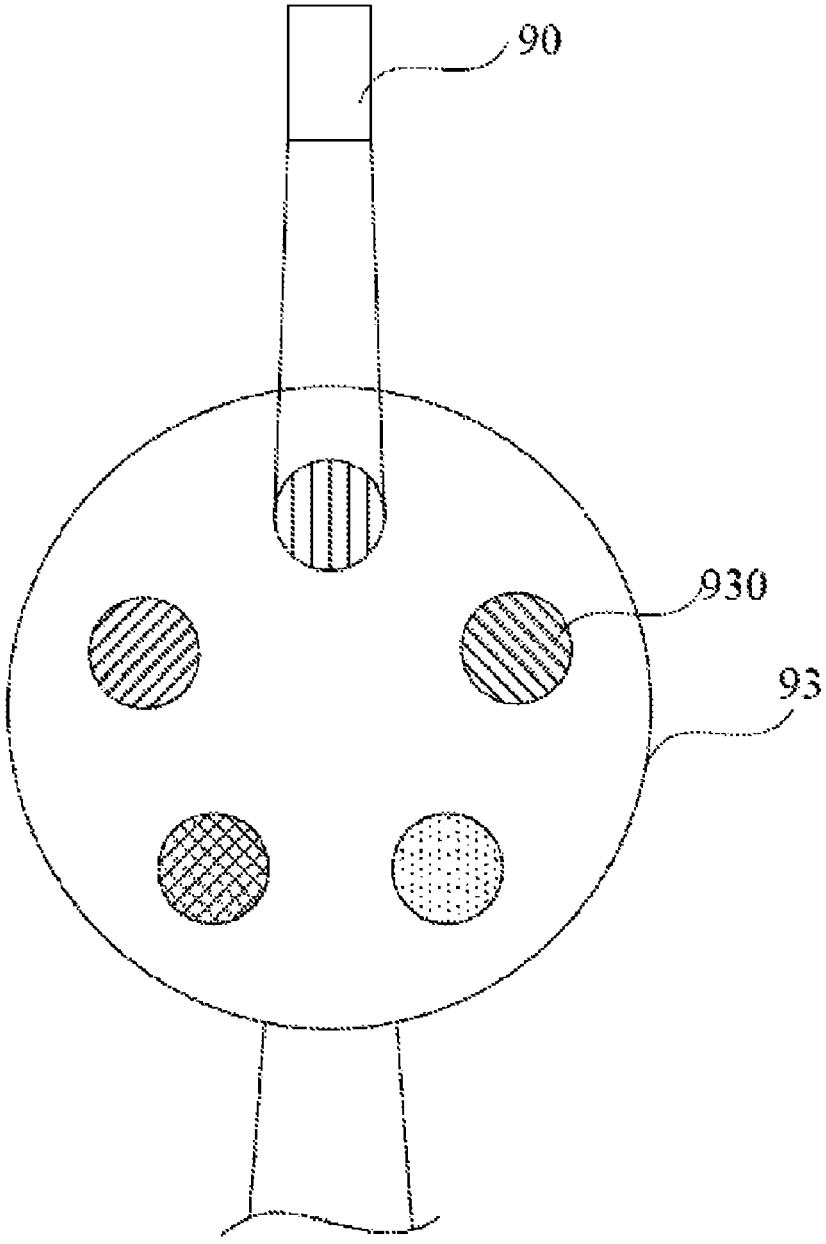

FIG. 2
PRIOR ART

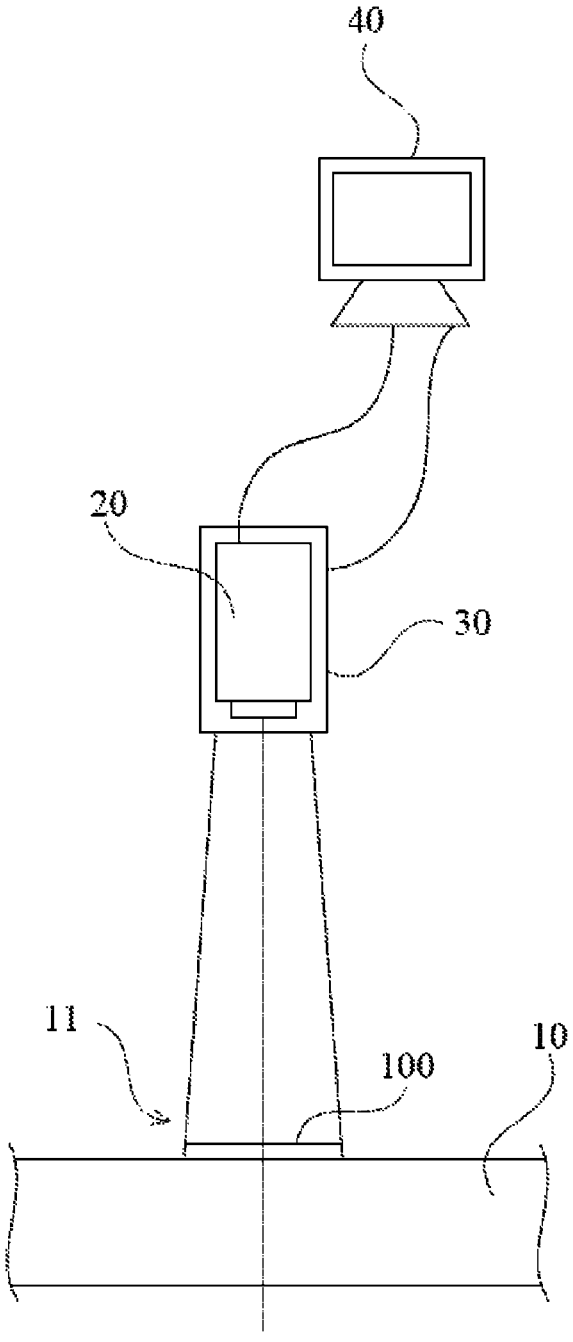

FIG. 3

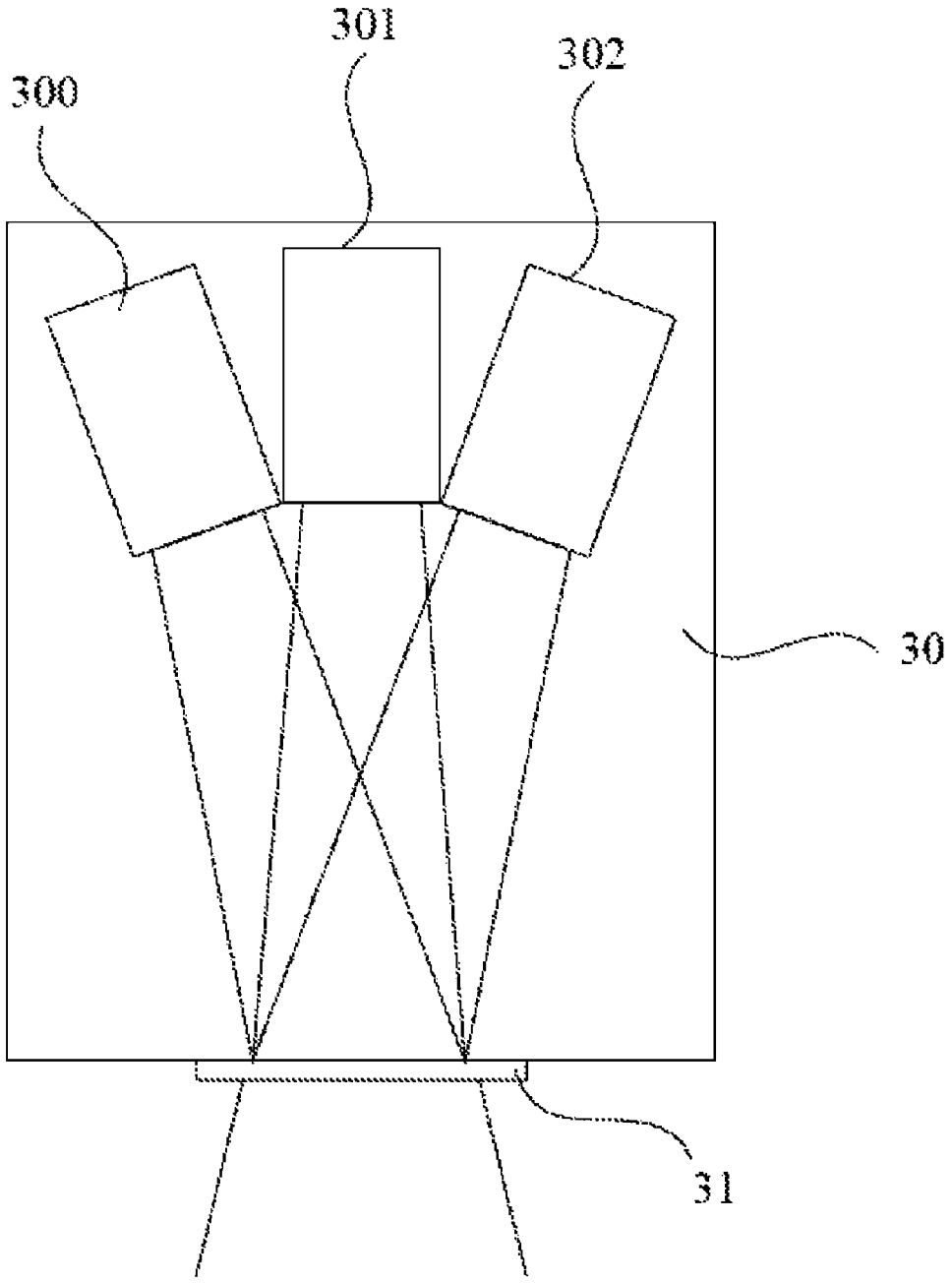

FIG. 4

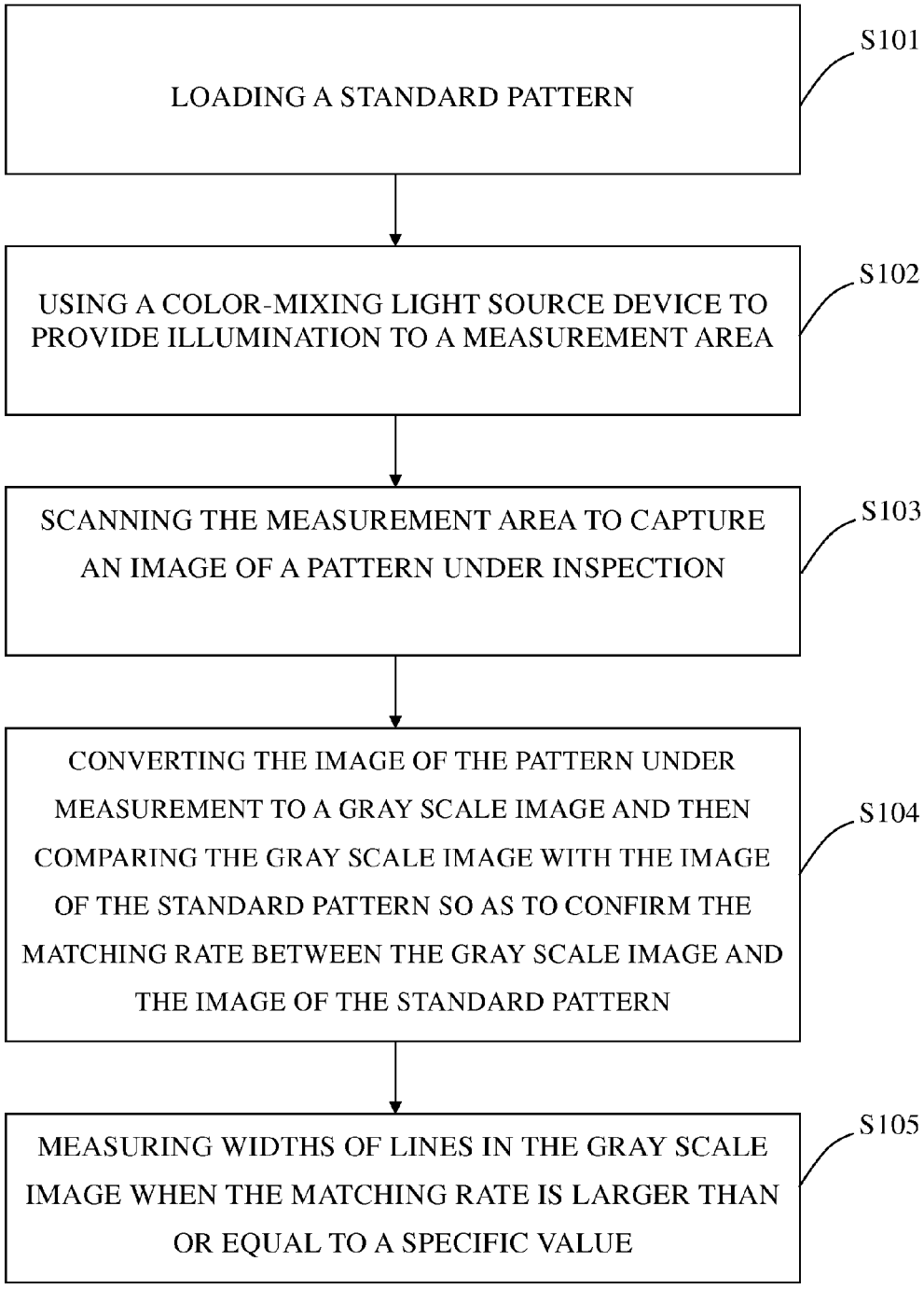
LOADING A STANDARD PATTERN
S101
USING A COLOR-MIXING LIGHT SOURCE DEVICE TO PROVIDE ILLUMINATION TO A MEASUREMENT AREA
S102
SCANNING THE MEASUREMENT AREA TO CAPTURE AN IMAGE OF A PATTERN UNDER INSPECTION
S103
CONVERTING THE IMAGE OF THE PATTERN UNDER MEASUREMENT TO A GRAY SCALE IMAGE AND THEN COMPARING THE GRAY SCALE IMAGE WITH THE IMAGE OF THE STANDARD PATTERN SO AS TO CONFIRM THE MATCHING RATE BETWEEN THE GRAY SCALE IMAGE AND THE IMAGE OF THE STANDARD PATTERN
S104
MEASURING WIDTHS OF LINES IN THE GRAY SCALE IMAGE WHEN THE MATCHING RATE IS LARGER THAN OR EQUAL TO A SPECIFIC VALUE
S105

FIG. 5

LINE-WIDTH MEASUREMENT DEVICE AND MEASUREMENT METHOD USING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a line-with measurement technology, especially to a line-width measurement device and a measurement method using the same that increase accuracy of line-width measurement.

2. Description of the Related Art

With the development of semiconductor manufacturing process, integrated circuit elements are progressively made much smaller. Therefore, in the semiconductor manufacturing process, control of critical dimension, such as line width, line pitch, etc. of fine circuit patterns on masks or wafers, is an important point. Generally, manufacturers use line-width measurement device to measure critical dimensions of circuit patterns, the line-width measurement device can be used to inspect if the line width or pitch is precise without deviation.

With reference to FIG. **1**, FIG. **1** is a schematic view of performing line-width measurement according to a conventional technology. The conventional technology uses an image capturing device **91** (such as a CCD camera) to capture an image from a pattern **92** under measurement, and then performs line-width measurement through computer processing. The image capturing device is usually assembled together with a light source device **90**. The light source device **90** provides illumination in a forward direction on a top of the pattern **92** under measurement, so that the image capturing device is able to capture a clear image.

The captured image is colored and will be converted into a gray scale image for the operation of line-width measurement. In general, before a computer performs line-width measurement of the gray scale image, it will first load an image of a standard pattern as a measuring reference. With reference to FIG. **2**, lights from the light source device **90** in FIG. **1** will pass through a filter **93** to provide suitable illumination so that the gray scale image converted from the captured image can have similar color contrast with the standard pattern for performing line-width measurement. The filter **93** used in the light source device for line-width measurement generally includes five kinds of filter units **930** having different colors to provide different choices of colored illumination so that different gray scale images can be obtained by using the lights projected through the different filter units **930**.

However, when the gray scale image of the pattern under measurement has a big difference in color contrast with the standard pattern, it will affect the accuracy of line-width measurement. Because foregoing filter **93** only provides five kinds of filter units **930**, the light source device **90** can only provide five kinds of colored illumination. Since different patterns under measurement may be made of materials having different reflection characteristics, only five choices of colored illumination will have limited room to adjust the gray scale image of the pattern under measurement.

Therefore, it is necessary to provide a line-width measurement device and a measurement method using the same to overcome the problems existing in the conventional technology.

SUMMARY OF THE INVENTION

In view of the shortcomings of the conventional technology, the main objective of the invention is to provide a line-width measurement device and a measurement method using the same that provide more illumination choices of colored light source, so as to solve the technical problem in which the gray scale image of the pattern under measurement has a difference in color contrast with the standard pattern and thereby affecting the accuracy of line-width measurement.

In order to achieve the foregoing object of the present invention, the present invention provides a line-width measurement device comprising:

a platform having a measurement area;

an image capturing device mounted above the platform and used to capture an image of a pattern under measurement in the measurement area;

a color-mixing light source device mounted above the platform, including a plurality of monochromatic light sources and adjusting brightness scale of each of the monochromatic light sources according to a matching rate between the image of the pattern under measurement and an image of a standard pattern.

In one embodiment of the present invention, the line-width measurement device further comprises a controller, and the controller is connected to the image capturing device and receives the image of the pattern under measurement captured by the image capturing device.

In one embodiment of the present invention, the controller is further connected to the color-mixing light source device and is used to control the color-mixing light source device to adjust the brightness scale of each of the monochromatic light sources according to the matching rate between the image of the pattern under measurement and the image of the standard pattern.

In one embodiment of the present invention, the controller is further used to convert the image of the pattern under measurement to a gray scale image, and then compare the gray scale image with the image of the standard pattern so as to confirm the matching rate between the gray scale image and the image of the standard pattern.

In one embodiment of the present invention, when the matching rate is larger than or equal to 80%, the controller is further used to measure widths of lines in the gray scale image; when the matching rate is lower than 80%, the controller then controls the color-mixing light source device to adjust the brightness scale of each of the monochromatic light sources.

In one embodiment of the present invention, the color-mixing light source device has a red light source, a blue light source and a green light source which provide 256 kinds of colored illumination by color mixing.

In one embodiment of the present invention, the red light source, the red light source, the blue light source and the green light source are at least one red light-emitting diode, at least one blue light-emitting diode and at least one green light-emitting diode, respectively.

The present invention further provides a line-width measurement method comprising steps of:

S**101**: loading a standard pattern;

S**102**: using a color-mixing light source device having a plurality of monochromatic light sources to provide illumination to a measurement area;

S**103**: scanning the measurement area to capture an image of a pattern under measurement;

S**104**: converting the image of the pattern under measurement to a gray scale image and then comparing the gray scale image with the image of the standard pattern so as to confirm the matching rate between the gray scale image and the image of the standard pattern; and

S**105**: when the matching rate is larger than or equal to a specific value, measuring widths of lines in the gray scale

image; or when the matching rate is lower than the specific value, adjusting the brightness scale of each of the monochromatic light sources and providing illumination again and re-executing steps **S103**, **S104** and **S105**.

In one embodiment of the present invention, the specific value is 80%.

In one embodiment of the present invention, the color-mixing light source device has a red light source, a blue light source and a green light source; and adjusting the brightness scale of each of the monochromatic light sources in step **S105** is to adjust the brightness scale of the red light source, the blue light source and the green light source.

The present invention further provides another line-width measurement device comprising:

a platform having a measurement area;

an image capturing device mounted above the platform and being used to capture an image of a pattern under measurement in the measurement area;

a controller connected to the image capturing device and receiving the image of the pattern under measurement captured by the image capturing device; and

a color-mixing light source device mounted above the platform, including a plurality of monochromatic light sources and adjusting brightness scale of each of the monochromatic light sources according to the matching rate between the image of the pattern under measurement and an image of a standard pattern so as to provide suitable color-mixed lights for illumination, wherein the color-mixing light source device includes a red light source, a blue light source and a green light source.

In one embodiment of the present invention, the color-mixing light source device further has an optical element; and the lights emitted by the monochromatic light sources are together projected onto the optical element and mixed with each other, and then are projected outwardly after passing through the optical element.

The present invention uses the color-mixing light source device to correspondingly provide illumination to the measurement area. The color-mixing light source device includes a plurality of monochromatic light sources and is able to adjust the brightness scale of each monochromatic light source according to the matching rate of the image of the pattern under measurement and the image of a standard pattern so that it can provide suitable mixed colored lights for illumination and further reduce the difference in color contrast between the gray scale image of the pattern under measurement and the image of the standard pattern, effectively increase the accuracy of line-width measurement.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an operational view of a conventional line-width measurement device;

FIG. **2** is an operational view showing that a light source device projecting lights through a filter of the conventional line-width measurement device;

FIG. **3** is an operation view of a preferred embodiment of a line-width measurement device in accordance with the present invention;

FIG. **4** is a schematic view of a preferred embodiment of a color-mixing light source device of the line-width measurement device in accordance with the present invention; and

FIG. **5** is a flow chart of a preferred embodiment of a line-width measurement method in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The foregoing objects, features and advantages adopted by the present invention can be best understood by referring to the following detailed description of the preferred embodiments and the accompanying drawings. Furthermore, the directional terms described in the present invention, such as upper, lower, front, rear, left, right, inner, outer, side and etc., are only directions referring to the accompanying drawings, so that the used directional terms are used to describe and understand the present invention, but the present invention is not limited thereto.

With reference FIG. **3**, FIG. **3** is an operation view of a preferred embodiment of a line-width measurement device in accordance with the present invention. The line-width measurement device comprises a platform **10**, an image capturing device **20** and a color-mixing light source device **30**.

The platform **10** has a measurement area **11**. The measurement area **11** is positioned on a top surface of the platform **10** for placing a pattern **100** under measurement (i.e. to be measured). The pattern under measurement **100** mainly refers to related components in the field of liquid crystal display device, such as an indium tin oxide (ITO) transparent electrode of a liquid crystal panel, data lines, scanning lines, etc., but is not limited thereto.

The image capturing device **20** is mounted above the platform **10** and may be attached to a bracket (not illustrated in the figures) mounted on the platform **10**. The image capturing device **20** preferably is aligned with and faces the measurement area **11** of the platform **10** and captures an image of the pattern **100** under measurement in the measurement area **11**.

The color-mixing light source device **30** is mounted above the platform **10**. The color-mixing light source device **30** correspondingly provides forward illumination to the measurement area **11**, and an incident direction of the forward illumination is perpendicular to the surface of the platform **10**. The color-mixing light source device **30** may be a light-emitting diode (LED) assembly. With further reference to FIG. **4**, FIG. **4** is a schematic view of a preferred embodiment of the color-mixing light source device **30** of the line-width measurement device in accordance with the present invention. The color-mixing light source device **30** includes a plurality of monochromatic light sources. In this embodiment, the monochromatic light sources include a red light source **300**, a blue light source **301** and a green light source **302**. The red light source **300**, the blue light source **301** and the green light source **302** preferably are at least one red light-emitting diode, at least one blue light-emitting diode and at least one green light-emitting diode, respectively. The color-mixing light source device **30** can adjust brightness scale of each of the monochromatic light sources according to the matching rate between the image of the pattern **100** under measurement and an image of a standard pattern so as to provide suitable color-mixed lights for illumination. When the monochromatic light sources are the red light source **300**, the blue light source **301** and the green light source **302**, the color-mixing light source device **30** can provide **256** kinds of colored illumination by color mixing. Furthermore, the color-mixing light source device **30** may further have an optical element **31**, such as a lens; and the lights emitted by the monochromatic light sources may be projected onto the optical element **31** together and be mixed with each other, and then be projected outwardly after passing through the optical element **31**.

The line-width measurement device may further comprises a controller **40**. The controller **40** is connected to the image capturing device **20** and is used to receive the image of the

pattern under measurement captured by the image capturing device **20**. In this embodiment, the controller **40** is further connected to the color-mixing light source device **30** and is used to control the color-mixing light source device **30** to adjust the brightness scale of each of the monochromatic light sources according to the matching rate between the image of the pattern **100** under measurement and the image of the standard pattern. The controller **40** is further used to convert the image of the pattern **100** under measurement to a gray scale image, and then compare the gray scale image with the image of the standard pattern so as to confirm the matching rate between the gray scale image and the image of the standard pattern. When the matching rate is larger than or equal to a specific value, the controller **40** then further measures widths of lines in the gray scale image; or when the matching rate is lower than the specific value, the controller **40** then further controls the color-mixing light source device **30** to adjust the brightness scale of each of the monochromatic light sources. In this embodiment, the specific value is preferably 80%, wherein the matching rate refers to the degree of similarity in color contrast between the gray scale image and the image of the standard pattern.

Since the color-mixing light source device **30** is used to provide illumination, the color-mixing light source device correspondingly adjust the brightness scale of each of the monochromatic light sources according to the matching rate between the pattern under measurement and the standard pattern, and thereby providing suitable colored illumination by mixing colored lights. Suitable colored illumination allows the gray scale image of the pattern under measurement to have similar color contrast with the standard pattern. In this way, the controller **40** can measure the widths of the lines in the pattern **100** under measurement more accurately.

The line-width measurement device may be operated by a line-width measurement method. The line-width measurement method, with reference to FIG. **5**, comprises steps of:

S**101**: loading a standard pattern;

S**102**: using a color-mixing light source device to provide illumination to a measurement area **11**;

S**103**: scanning the measurement area **11** to capture an image of a pattern **100** under measurement;

S**104**: converting the image of the pattern **100** under measurement to a gray scale image and then comparing the gray scale image with the image of the standard pattern so as to confirm the matching rate between the gray scale image and the image of the standard pattern; and

S**105**: when the matching rate is larger than or equal to a specific value, then further measuring widths of lines in the gray scale image.

Besides, in step S**105**, when the matching rate is lower than the specific value, then further adjust the brightness scale of each of the monochromatic light sources and provide illumination again and re-execute steps S**103**, S**104** and S**105**.

In more detail, the step S**101** is to use the controller **40** to load an image of the standard pattern. The step S**102** is to use a plurality of monochromatic light sources of the color-mixing light source device to provide illumination. The step S**103** is to use the image capturing device **20** to scan the measurement area **11** to capture the image of the pattern **100** under measurement. The step S**104** is to use the controller **40** to convert the image of the pattern **100** under measurement to a gray scale image and use the controller **40** to compare the gray scale image with the image of the standard pattern so as to confirm the matching rate of the gray scale image and the image of the standard pattern. The step S**105** is to use the controller **40** to determine that when the matching rate is larger than or equal to a specific value, the controller **40** then further measures width of lines in the gray scale pattern; and if the controller **40** determine that the matching rate is lower than the specific value, the controller **40** then further control the color-mixing light source device **30** to adjust the brightness scale of each of the monochromatic light sources, and provide illumination again and re-execute steps S**103**, S**104** and S**105**. In an embodiment of the line-width measurement method, the specific value is 80%.

By the above description, comparing with the conventional line-width measurement device that provides only a few choices of colored illumination due to a limited variety of the filter units of a filter, the present invention uses a color-mixing light source device having a plurality of monochromatic light sources that are able to provide 256 kinds of colored illumination by color mixing. Hence, the measurement method of the present invention can provide suitable colored illumination according to the matching rate of the image of the pattern under measurement and the image of a standard pattern, and thereby reducing the difference in color contrast between the gray scale image of the pattern under measurement and the image of the standard pattern to effectively increase the accuracy and stability of line-width measurement.

The present invention has been described with a preferred embodiment thereof and it is understood that many changes and modifications to the described embodiment can be carried out without departing from the scope and the spirit of the invention that is intended to be limited only by the appended claims.

What is claimed is:

1. A line-width measurement device comprising:

a platform having a measurement area;

an image capturing device mounted above the platform and being used to capture an image of a pattern under measurement in the measurement area;

a controller connected to the image capturing device and receiving the image of the pattern under measurement captured by the image capturing device; and

a color-mixing light source device mounted above the platform, including a plurality of monochromatic light sources and adjusting brightness scale of each of the monochromatic light sources according to a matching rate between the image of the pattern under measurement and an image of a standard pattern so as to provide suitable color-mixed lights for illumination, wherein the color-mixing light source device includes a red light source, a blue light source and a green light source, wherein the controller is further used to convert the image of the pattern under measurement to a gray scale image, and then compare the gray scale image with the image of the standard pattern so as to confirm the matching rate between the gray scale image and the image of the standard pattern; the controller is further used to measure the widths of lines in the gray scale image when the matching rate is larger than or equal to 80%, and to control the color-mixing light source device to adjust the brightness scale of each of the monochromatic light sources when the matching rate is lower than 80%.

2. The line-width measurement device as claimed in claim **1**, wherein the color-mixing light source device further has an optical element; and the lights emitted by the monochromatic light sources are projected onto the optical element together and mixed with each other, and then are projected outwardly after passing through the optical element.

3. The line-width measurement device as claimed in claim **1**, wherein the controller is further connected to the color-mixing light source device and is used to control the color-mixing light source device to adjust the brightness scale of

each of the monochromatic light sources according to the matching rate between the image of the pattern under measurement and the image of the standard pattern.

4. The line-width measurement device as claimed in claim **1**, wherein the color-mixing light source device has a red light source, blue light source and a green light source which provide 256 kinds of colored illumination by color mixing.

5. The line-width measurement device as claimed in claim **1**, wherein the blue light source and the green light source are at least one red light-emitting diode, at least one blue light-emitting diode and at least one green light-emitting diode, respectively.

6. A line-width measurement device comprising:

a platform having a measurement area;

an image capturing device mounted above the platform and used to capture an image of a pattern under measurement in the measurement area;

a color-mixing light source device mounted above the platform, including a plurality of monochromatic light sources and adjusting brightness scale of each of the monochromatic light sources according to a matching rate between the image of the pattern under measurement and the image of a standard pattern, wherein the controller is further used to convert the image of the pattern under measurement to a gray scale image, and then compare the gray scale image with the image of the standard pattern so as to confirm the matching rate between the gray scale image and the image of the standard pattern; the controller is further used to measure widths of lines in the gray scale image when the matching rate is larger than or equal to 80%, and to control the color-mixing light source device to adjust the brightness scale of each of the monochromatic light sources when the matching rate is lower than 80%.

7. The line-width measurement device as claimed in claim **6**, wherein the line-width measurement device further comprises a controller, and the controller is connected to the image capturing device and receives the image of the pattern under measurement captured by the image capturing device.

8. The line-width measurement device as claimed in claim **7**, wherein the controller is further connected to the color-mixing light source device and is used to control the color-mixing light source device to adjust the brightness scale of each of the monochromatic light sources according to the matching rate between the image of the pattern under measurement and the image of the standard pattern.

9. The line-width measurement device as claimed in claim **6**, wherein the color-mixing light source device has a red light source, a blue light source and a green light source which provide 256 kinds of colored illumination by color mixing.

10. The line-width measurement device as claimed in claim **9**, wherein the red light source, the blue light source and the green light source are at least one red light-emitting diode, at least one blue light-emitting diode and at least one green light-emitting diode, respectively.

11. The line-width measurement device as claimed in claim **6**, wherein the color-mixing light source device further has an optical element; and the lights emitted by the monochromatic light sources are together projected onto the optical element and mixed with each other, and then are projected outwardly after passing through the optical element.

12. A line-width measurement method comprising steps of:

S**101**: loading a standard pattern;

S**102**: using a color-mixing light source device having a plurality of monochromatic light sources to provide illumination to a measurement area;

S**103**: scanning the measurement area to capture an image of a pattern under measurement;

S**104**: converting the image of the pattern under measurement to a gray scale image and then comparing the gray scale image with the image of the standard pattern so as to confirm a matching rate between the gray scale image and the image of the standard pattern; and

S**105**: when the matching rate is larger than or equal to 80%, measuring widths of lines in the gray scale image; or when the matching rate is lower than 80%, adjusting the brightness scale of each of the monochromatic light sources and providing illumination again and re-executing steps S**103**, S**104** and S**105**.

13. The line-width measurement method as claimed in claim **12**, wherein the color-mixing light source device has a red light source, a blue light source and a green light source; and adjusting the brightness scale of each of the monochromatic light sources in step S**105** is to adjust the brightness scale of the red light source, the blue light source and the green light source.

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